Role of Renewable Energy in Mitigating Air Pollution and Greenhouse Gas Emissions

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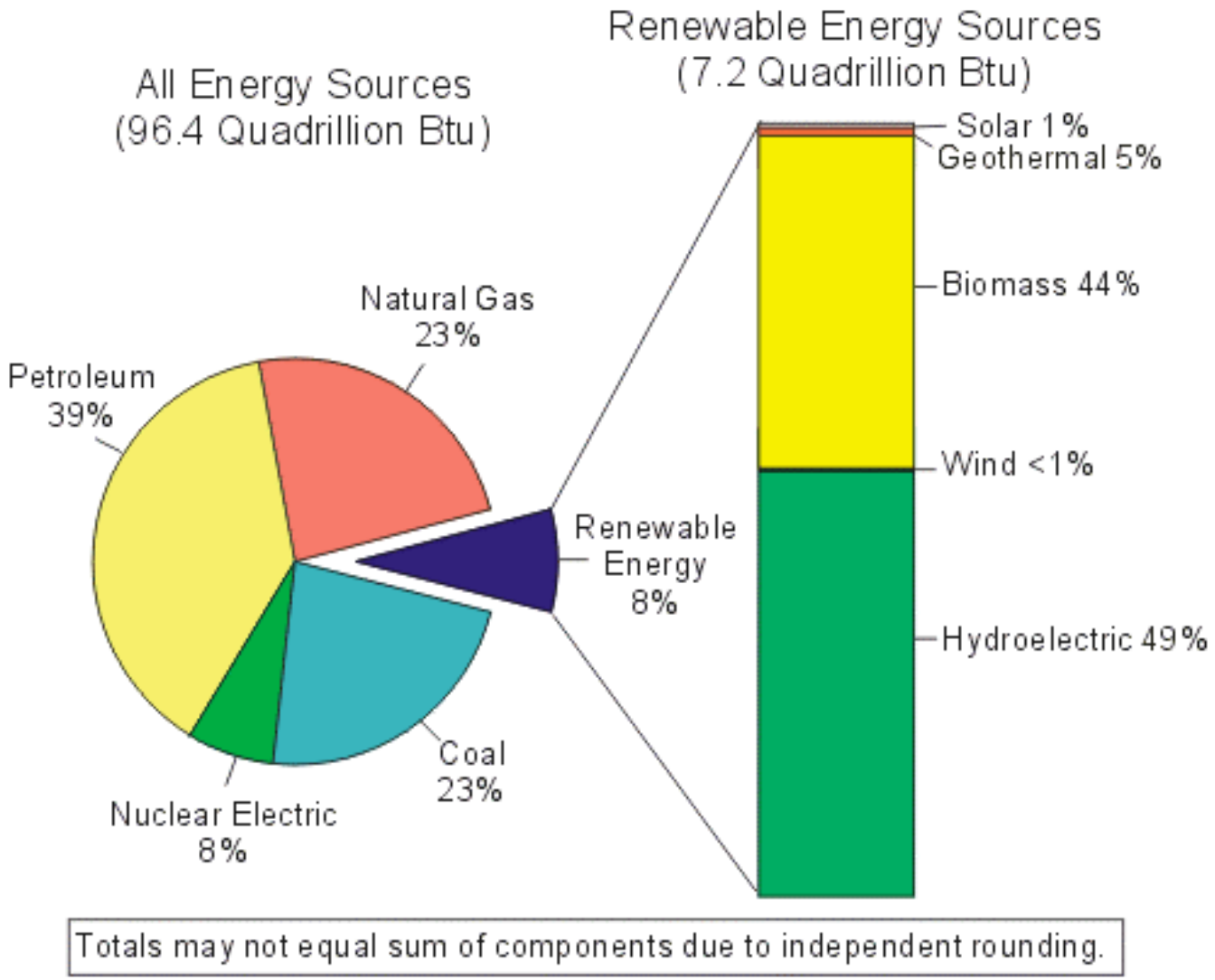
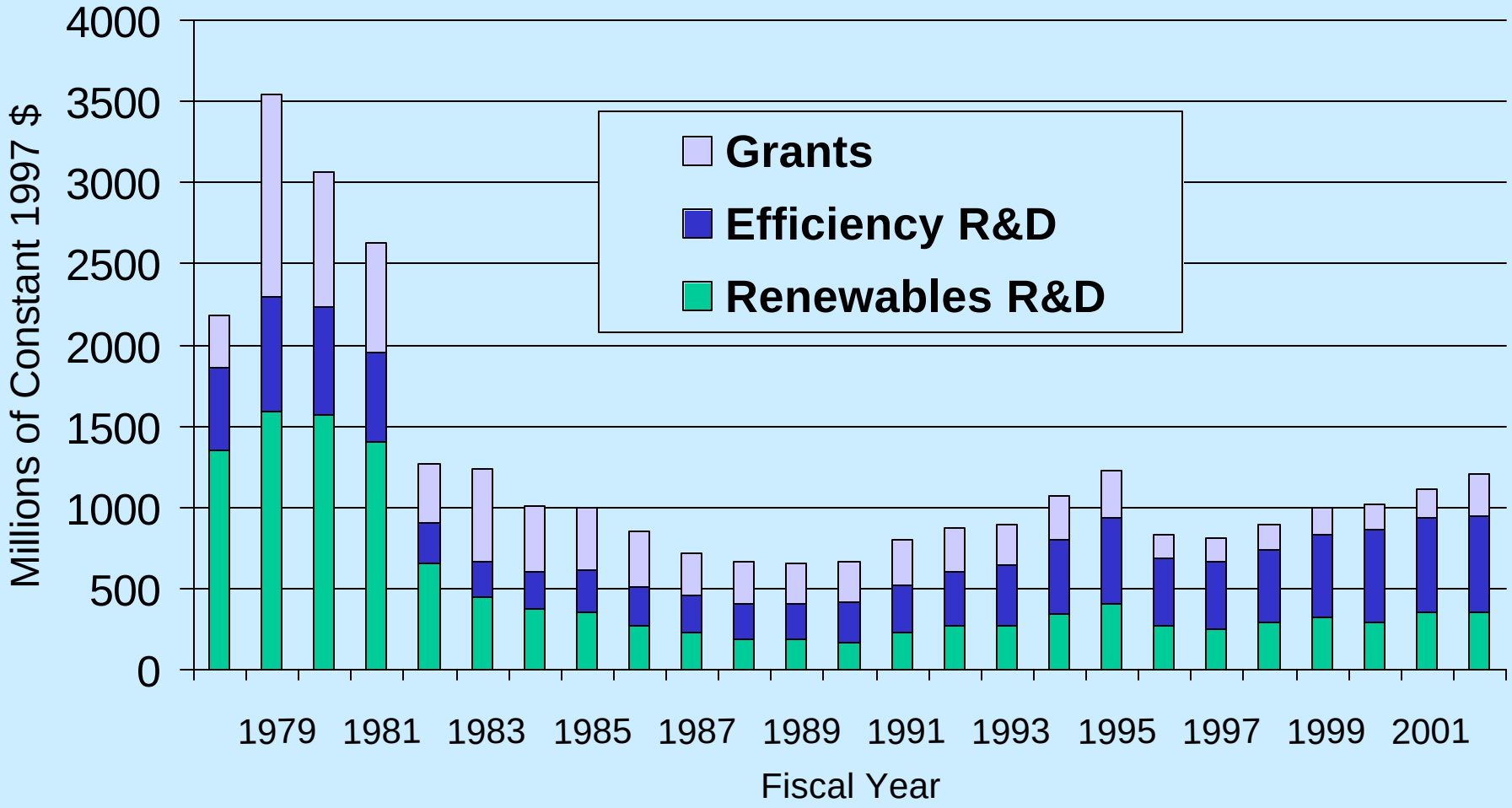
U.S. Renewable Energy Use



Source: US Energy Information Administration (March, 2001). Renewable Energy Annual 2000. http://www.eia.doe.gov/cneaf/solar.renewables/page/rea_data/figh1.html

Energy Efficiency and Renewable Energy Funding, FY1978-2002



Source: EERE Office of Planning, Budget and Management

DOE - EERE Program Areas

- Solar
- Wind & Hydropower
- Geothermal
- Biomass
- DE, Electricity Infrastructure, & Reliability
- FreedomCAR & Vehicle Technologies
- Hydrogen & Infrastructure
- Industrial Technologies
- Building Technologies
- Weatherization & Intergovernmental Grants
- FEMP

Research Is Reducing RET Costs

Photovoltaics

1980:
$1.00/kWh

2000:
~$0.20/kWh

2010:
~$0.10/kWh

R&D Focus:

- High performance PV Cells
- Thin-film partnerships
- Manufacturing

Concentrating Solar Power

1980:
$0.60/kWh

2000:
~$0.10/kWh

R&D Focus:

- Improved dish reliability
- Reduced trough costs
- Explore feasibility of PV dish systems

2010:
~$0.05/kWh

Wind Energy Systems

1979:
40 cents/kWh

2000:
4-6 cents/kWh

107 MW Lake Benton wind farm, MN

2007:
2-4 cents/kWh

R&D Focus:

- Increased Turbine Size
- R&D Advances
- Manufacturing Improvements

Geothermal Energy

1985:
15-16 cents/kWh

2000:
5- 8 cents/kWh

Mammoth Pacific Geothermal Facility

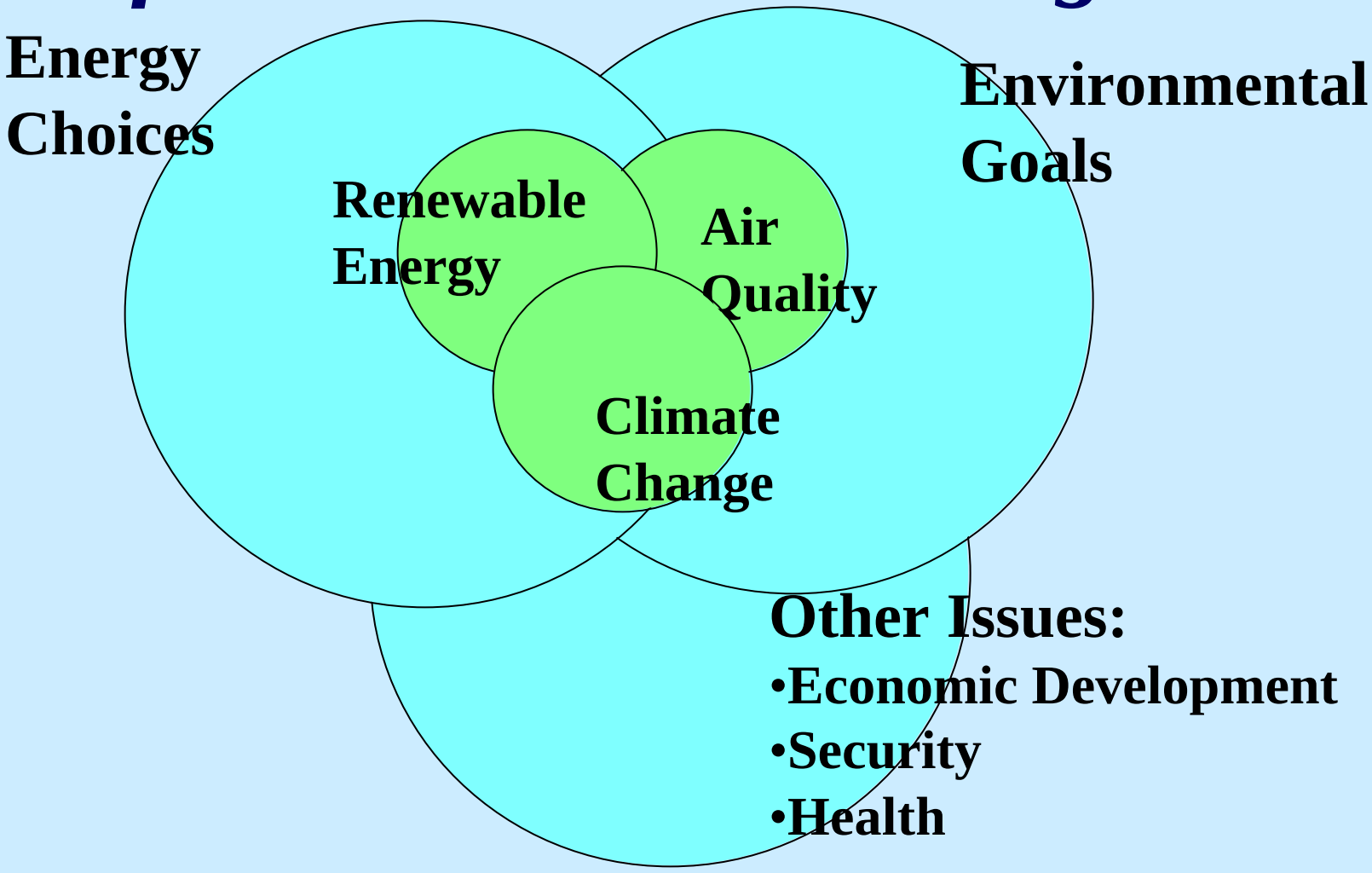
2003:
4- 6 cents/kWh

R&D Focus:

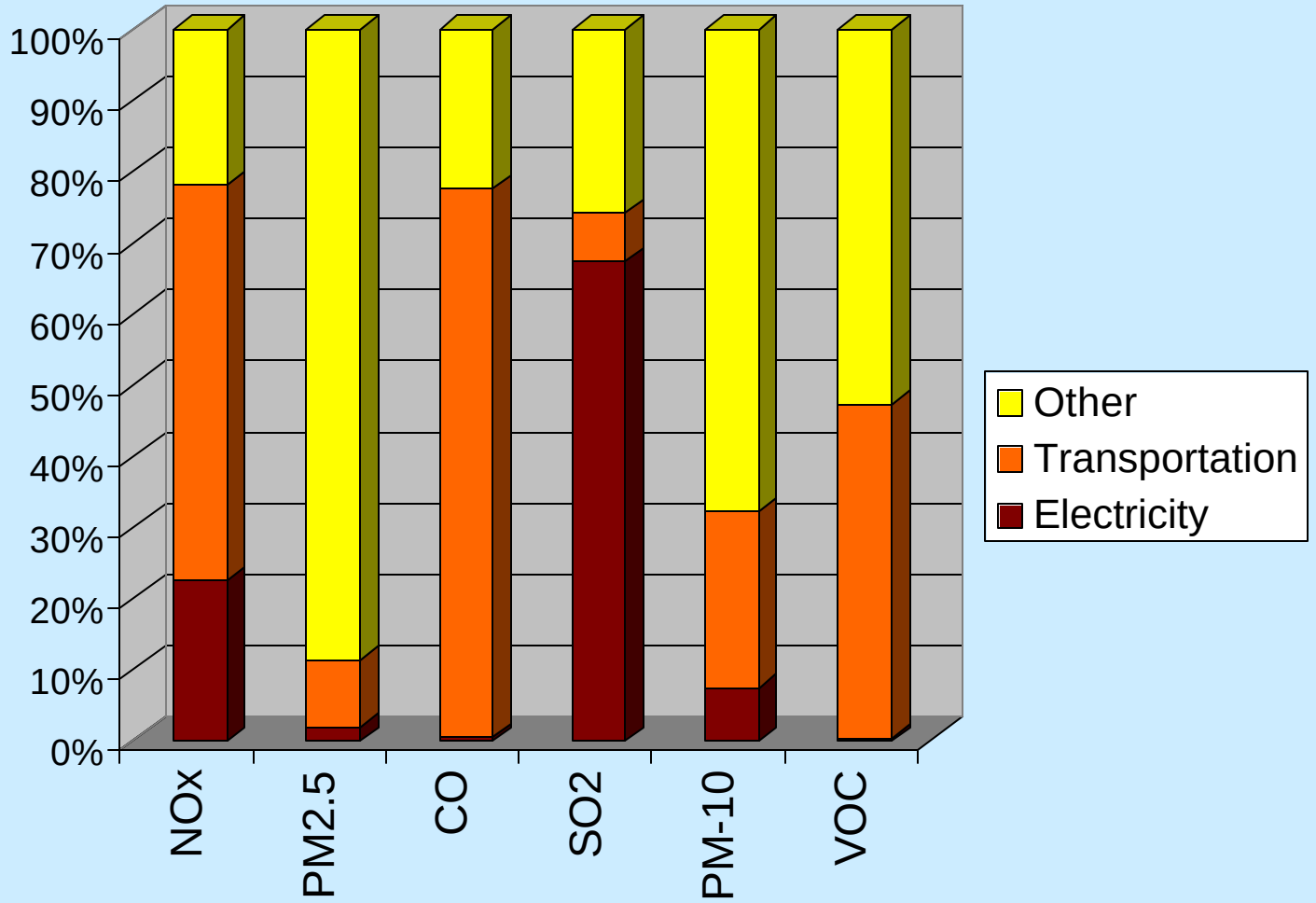
- Improved drilling technology
- Economies of scale
- Reduced cost of finance

Source: U.S. DOE

Renewable Energy Technology for Air Emissions Mitigation



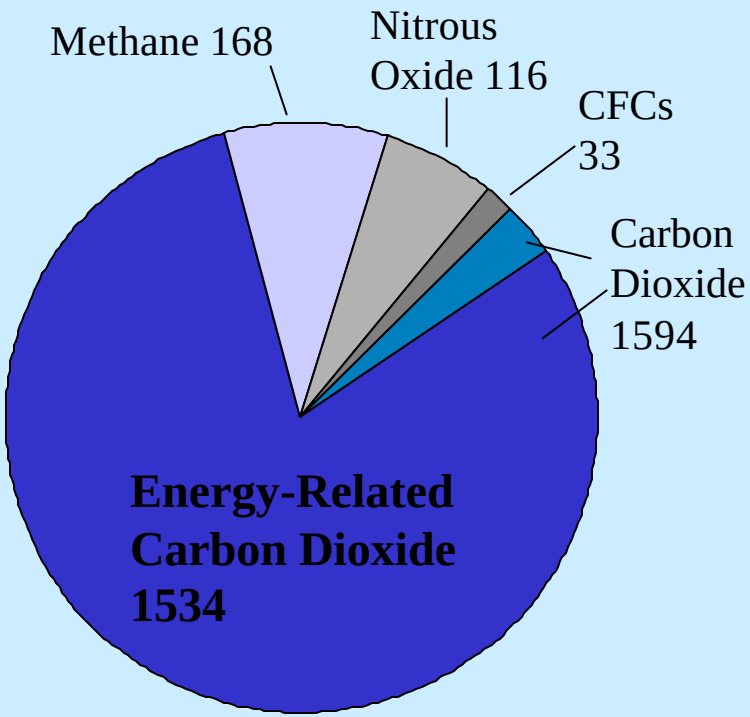
Air Emissions from Transportation and Electricity Generation



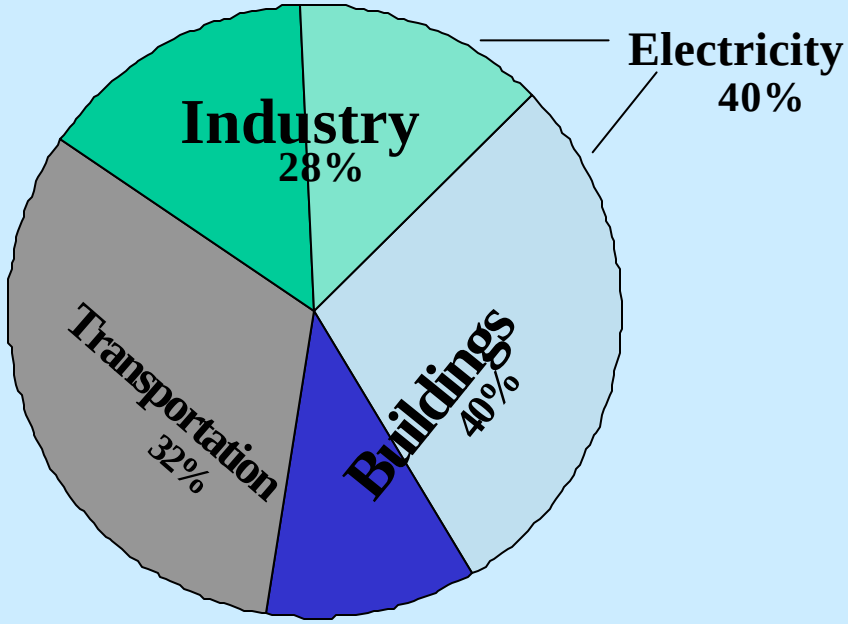
Source: USEPA, National Air Quality and Emissions Trends Report (2001)

U.S. GHG Emissions and Energy

million metric tons of carbon



Total Greenhouse Gases Emitted



Sources of CO_2 Emissions

by Energy Sector

Source: U.S. EPA (April 2002). Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2000, Tables ES1, 9

The Framework Convention

- A decade ago the United States and more than 160 other nations created the Framework Convention on Climate Change.

- The FCCC has as its ultimate objective

The ultimate objective of this [The Framework] Convention…is…the…stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner. **Article 2 (UNFCCC, 1992)**

Stabilizing Concentrations …

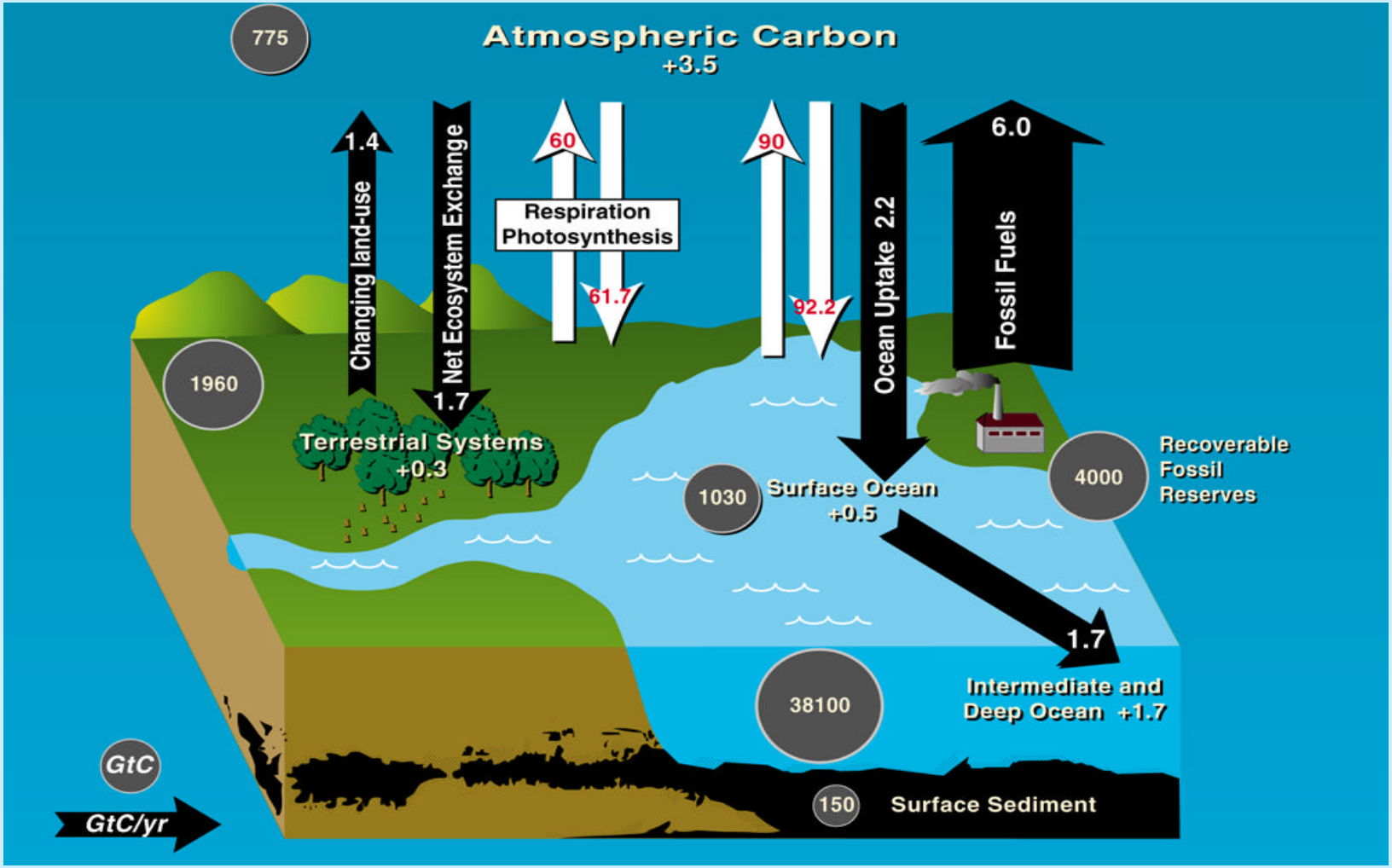
… has non-trivial implications for energy.

- Any CO_2 concentration is associated with CUMULATIVE NET EMISSIONS from pre-industrial times by everyone, everywhere on the planet.

- Global Net CO_2 Emissions must eventually approach ZERO.

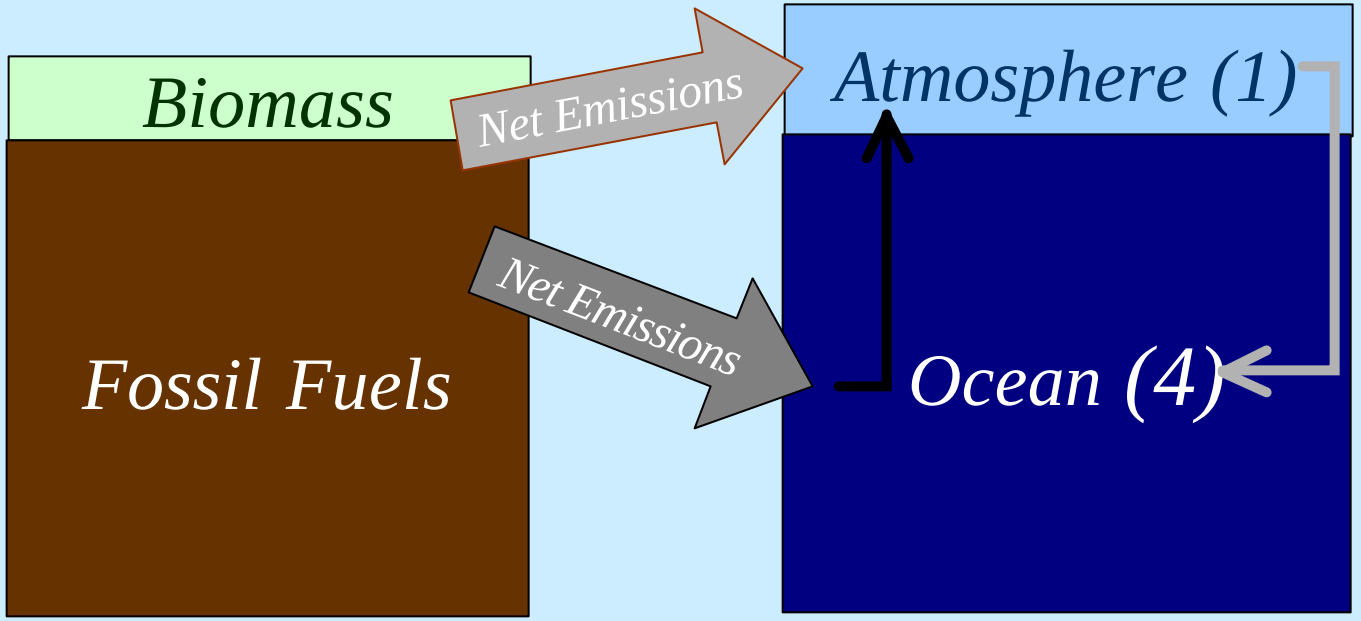
… for any stabilization concentration.

Global Carbon Cycle



Source: ORNL

Why Zero?

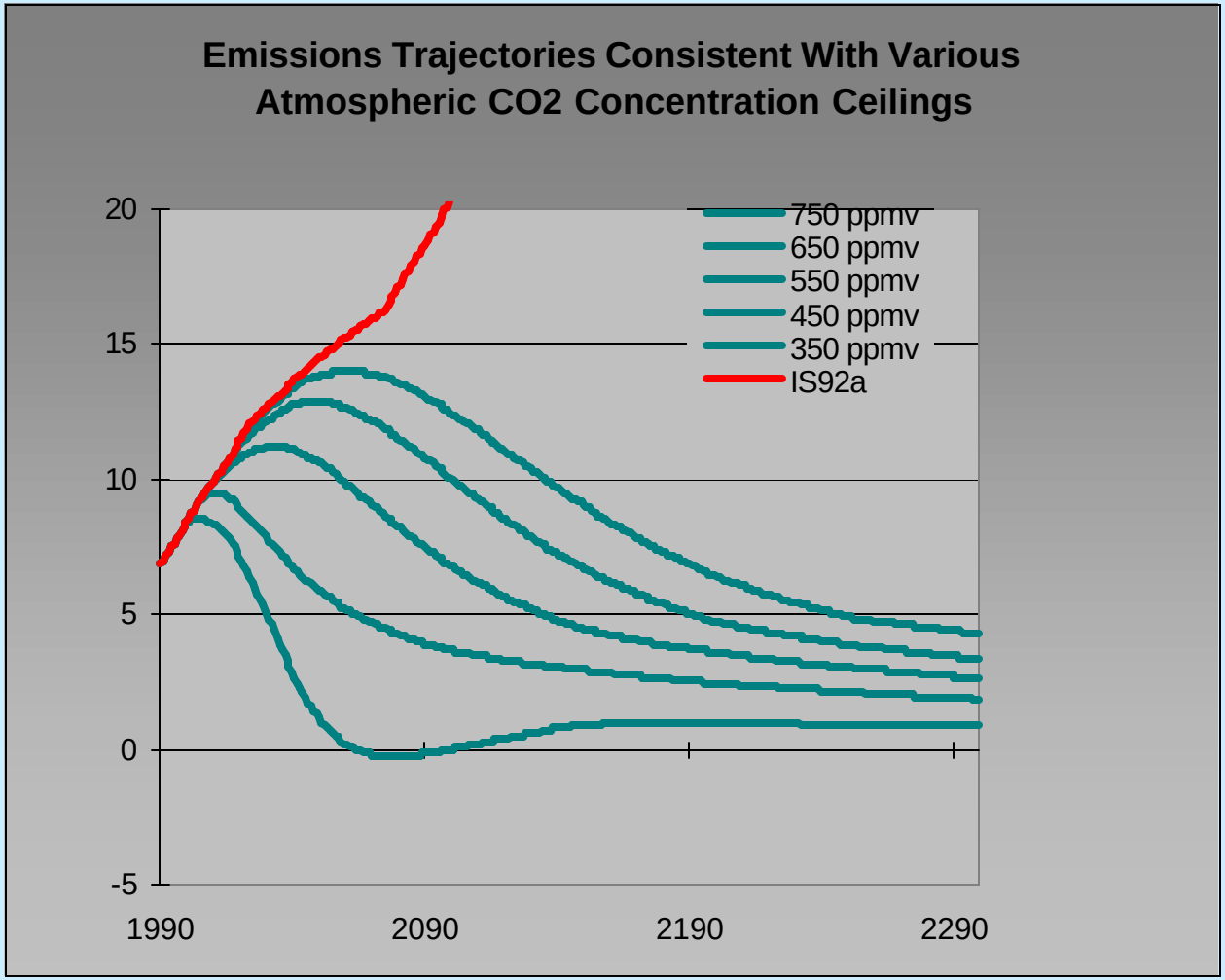


Long Term Distribution between ocean and atmosphere ~1:4

Stabilizing the Concentration of CO_2

Emissions Must Peak & Decline

Cumulative emissions determine the concentration.



Reference Emissions

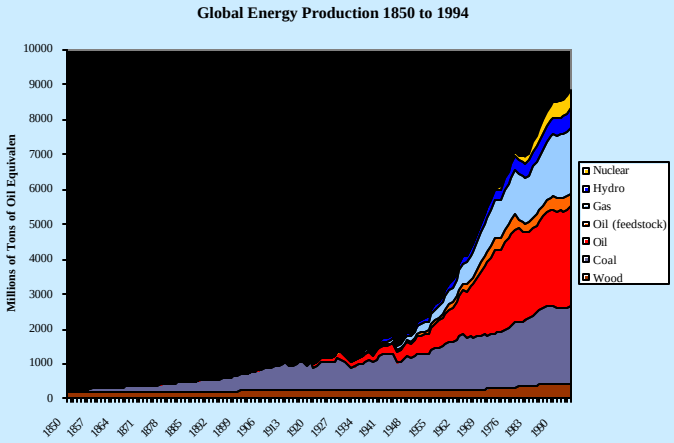
The problem may go away on its own—BUT, don't count on it. There are plenty of fossil fuels available to fuel the global economy for hundreds of years.

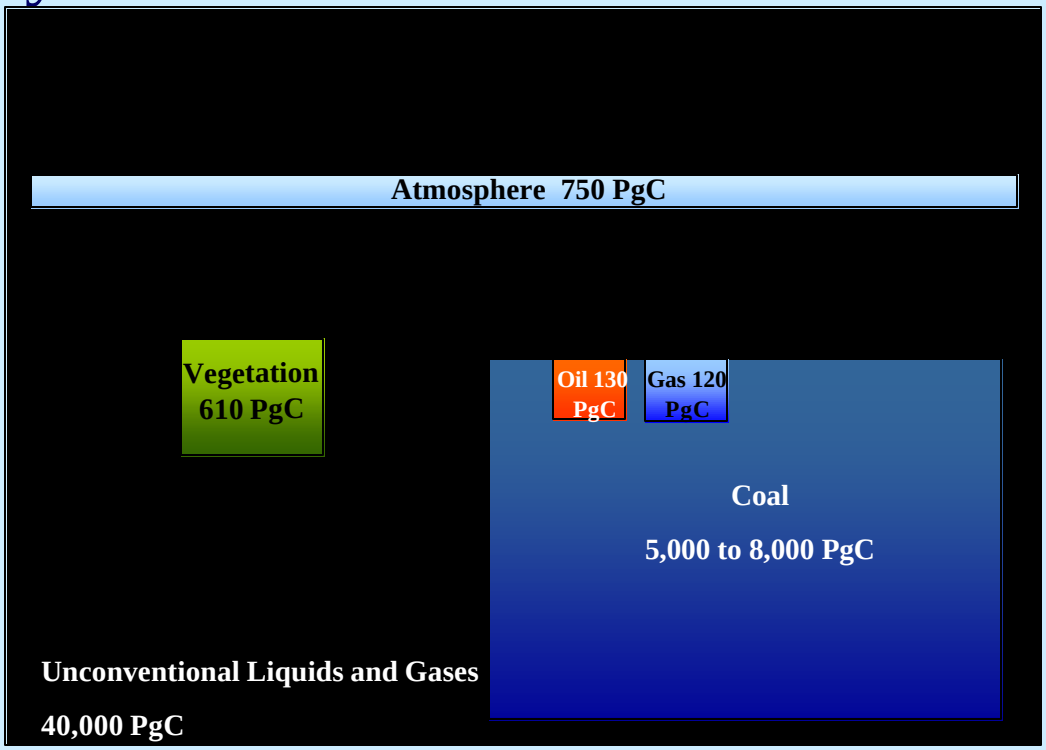
Fossil fuels are abundant,

Large relative to the stock in the atmosphere,

The backbone of the present global energy system, and

May continue to be used.



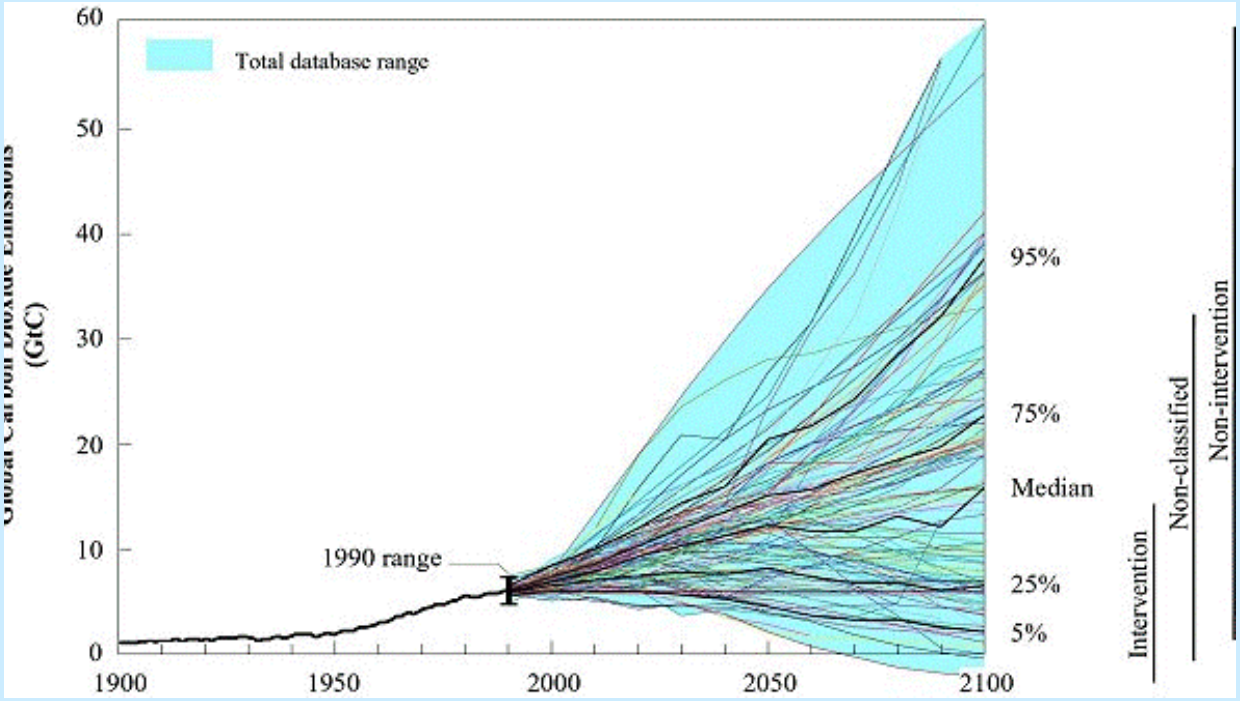


Reference Emissions

A wide variety of visions of the future development of the world can be found in the literature.

Some are consistent with stabilizing the concentration of greenhouse gases,

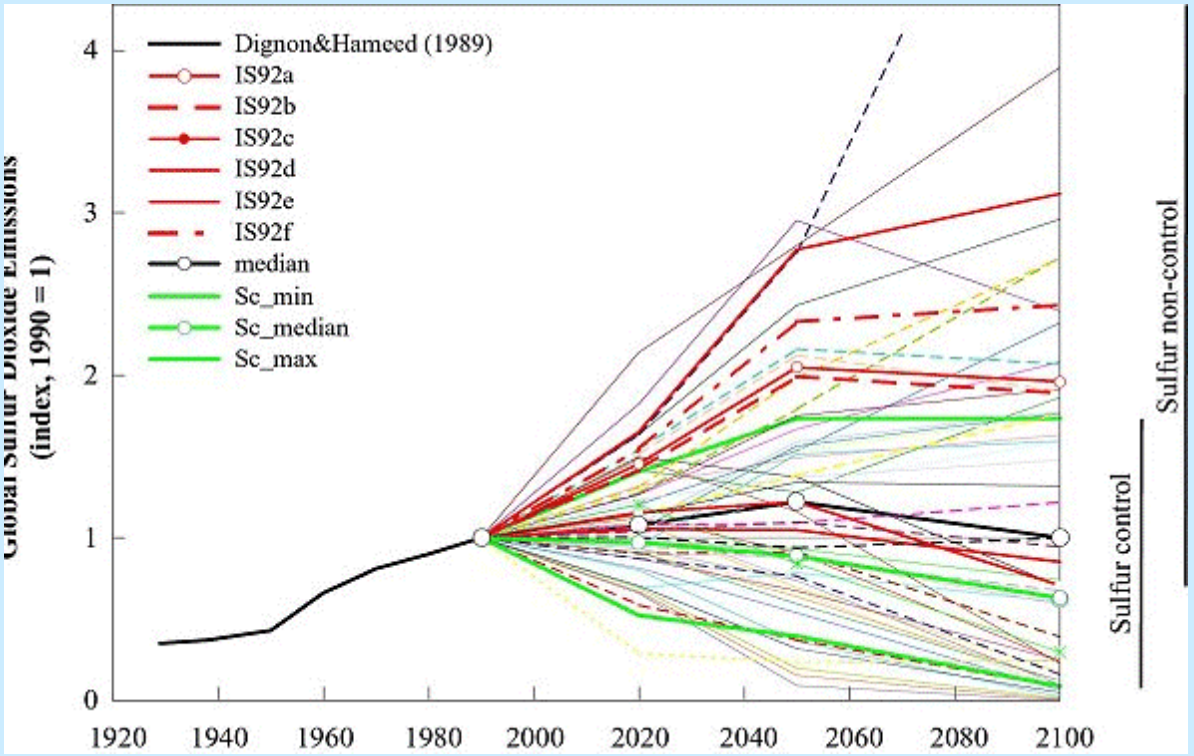
Many are not.



Source: http://sres.ciesin.org/htmls/published_report.html

Reference Emissions

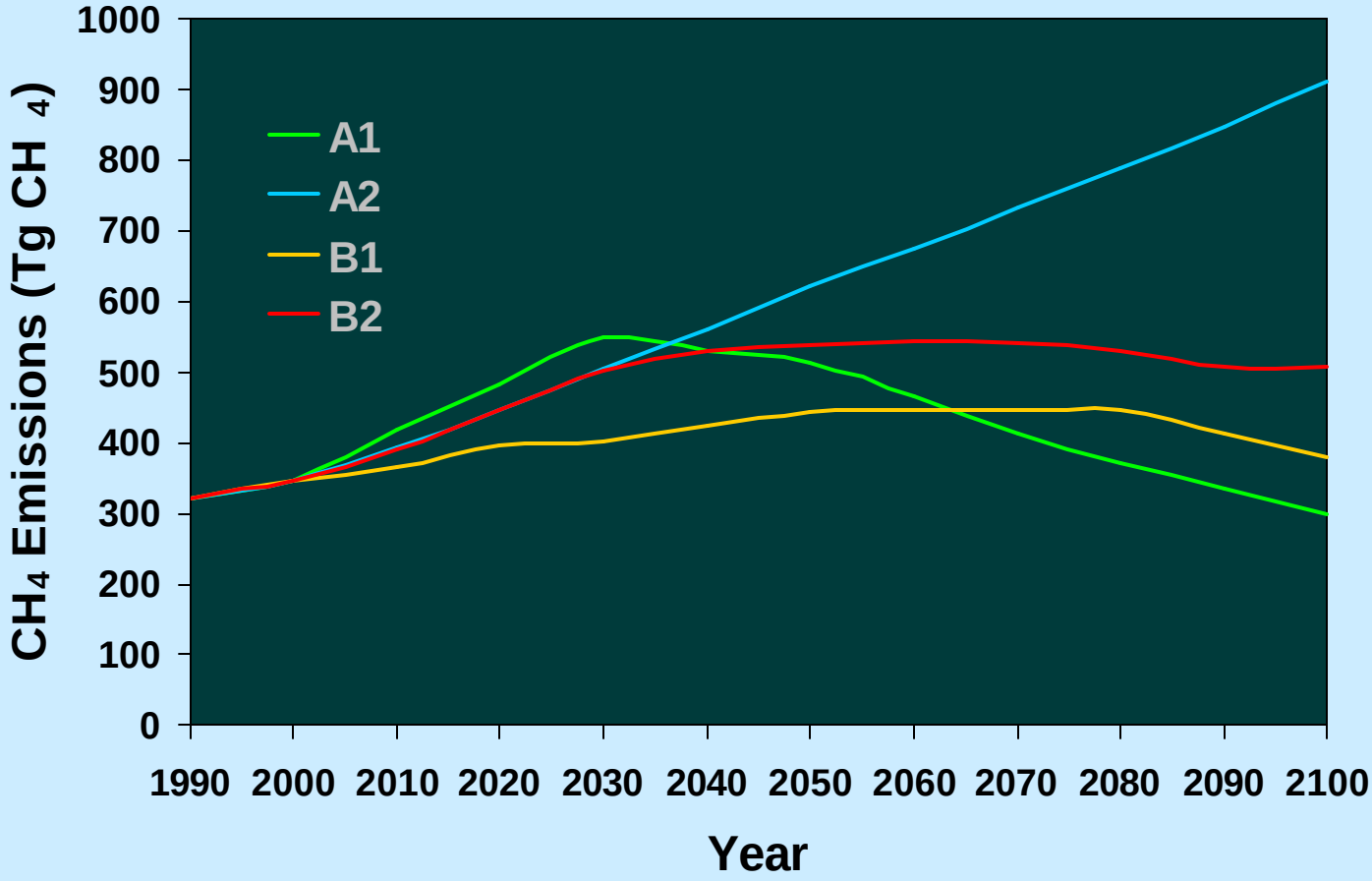
Sulfur emissions are similar.



Source: http://sres.ciesin.org/htmls/published_report.html

Reference Emissions

Methane emissions are similar.



Stabilizing the Concentration of CO_2

Is inherently A DYNAMIC, LONG TERM, GLOBAL problem.

Two tasks

- ***Provide for a long-term transition to a net-zero carbon emission global energy system.***
- ***Minimize cumulative emissions in the interim.***

Stabilizing the Concentration of CO_2

Requires Technology and Policy in Three Different Time Frames

- **The Long Term**—*global carbon emissions must approach zero.*
- **The Mid Term**—*transition from emitting to non-emitting world.*
- **Near Term**
  - *Array technology & energy system options.*
  - *Insure assumed reference technologies are delivered.*
  - *Minimize cumulative emissions with incremental technology improvements*
  - *Make progress with non-CO_2 gases and aerosols.*

Overview of U.S. Climate Policy

- Presidential Announcement on Feb.14 ,'02
  - Affirmation of Commitment to UNFCCC
  - Goal: Reduce GHG Intensity (emissions per $ GDP) by 18% by 2012
- Initiatives to Achieve Goal
  - Increased RD&D Investment for Climate Change
  - Federal GHG Registry
  - Financial Incentives

RD&D Investment for Climate Change

- Oversight at Cabinet Level: Committee on Climate Change Science and Technology Integration
- Proposed Research Budgets:
  - $588 million for Energy Conservation
  - $408 million for Renewable Energy
- National Energy Policy Recommendations

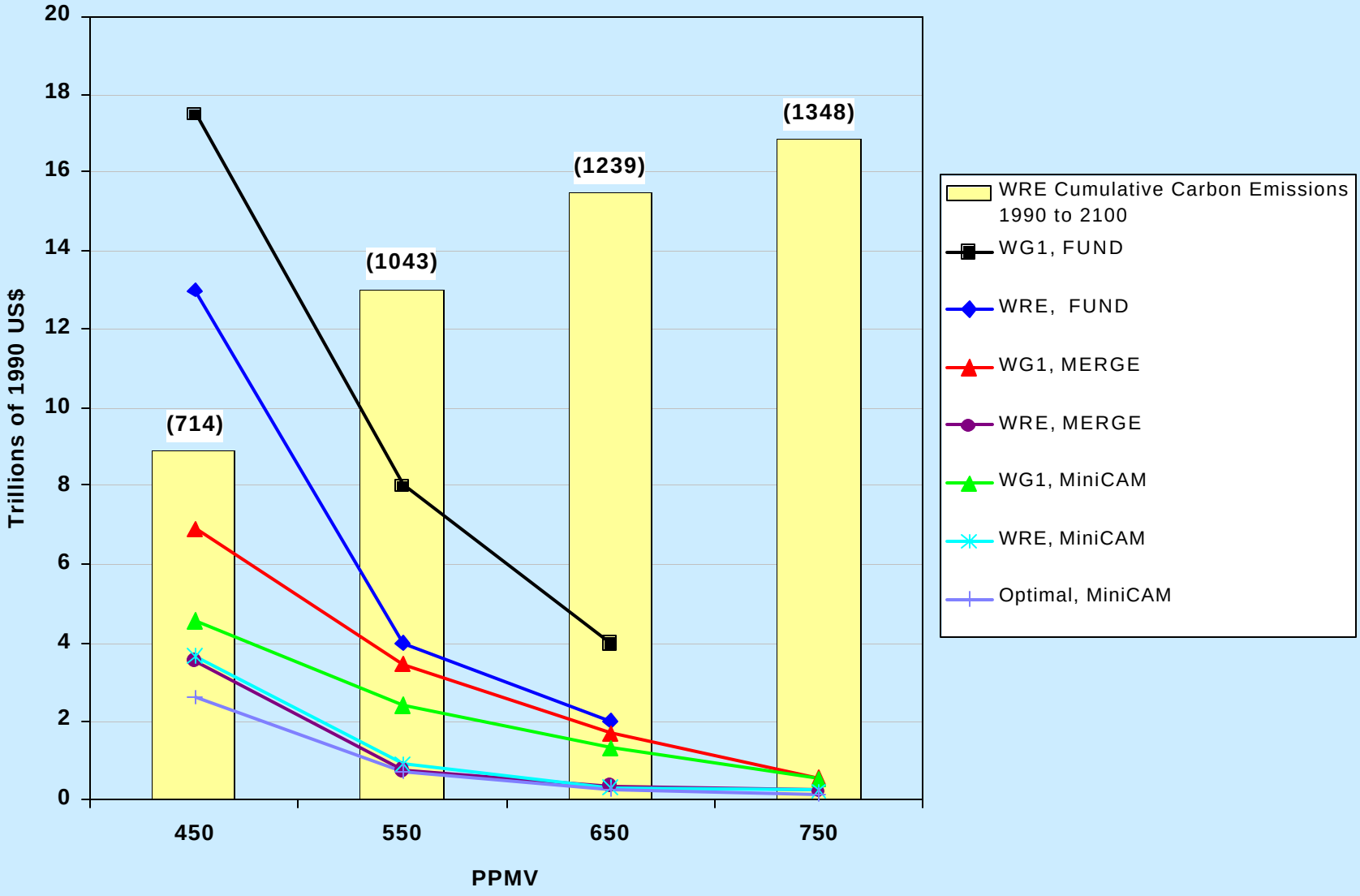
Federal GHG Reduction and Sequestration Registry

- Improve Energy Policy Act 1605(b) voluntary emission reduction registration
- Give emissions reductions credits
- Comprehensive recognition for companies
  - GHG Capture and Sequestration
  - Mitigation (Energy Efficiency, Fuel Switching)
  - Process Changes
- DOE Seeking Public Comment on Registry Design

The Cost of Emissions Mitigation Is a Highly Contingent Value

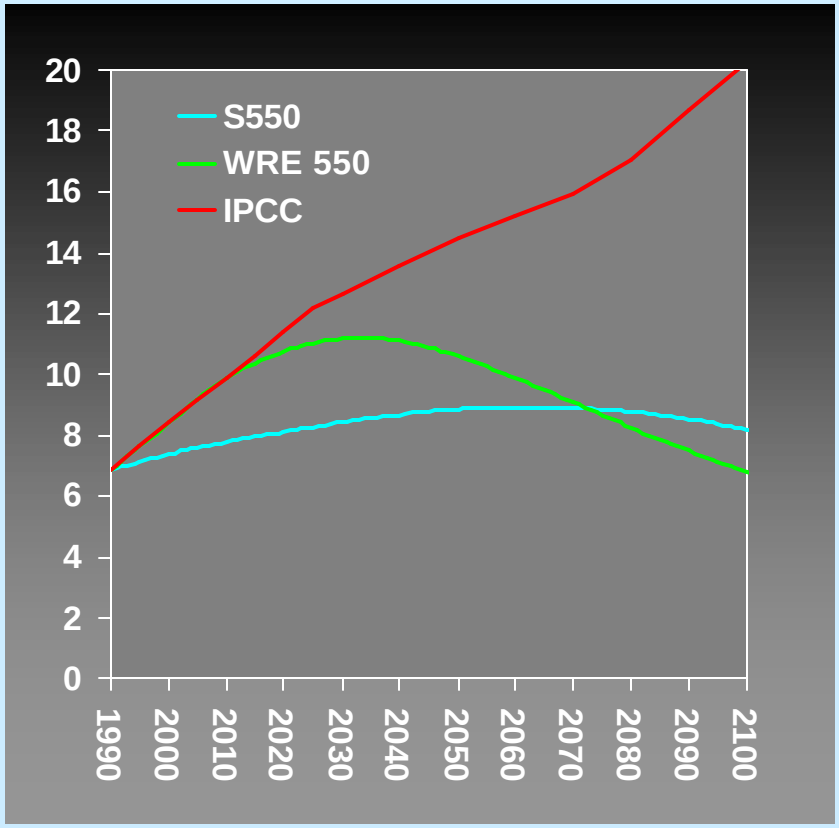
- **Reference emissions** (scale of the future problem),
- **Technology** and technological change
- **Policy Instrument** (fiscal, trade, banking, regulation, tax structure change)
- **Policy Stringency** (350 ppmv or 750 ppmv ceiling?)
- **Coverage of the Policy** (the world, a single nation, a sector, greenhouse gases)
- **Perspective** (world, a nation, an industry, an individual)
- **Analytical Approach** (top-down, bottom-up)
- **Implementation** (timing, restrictions, measurement, etc.)

Cost & Concentrations



Timing

A gradual transition …



- Minimizes premature retirement of capital stocks,
- Technology development implies lower emissions mitigation costs in the future relative to the present,
- The marginal cost of capital is positive, and
- Cumulative emissions can be significantly higher for a century.

Implementation

Cost estimates in the literature show relatively low—*single digit fraction of gross world product—to stabilize the concentration of CO_2 at 550 ppmv.*

Most analysis assumes an idealized world—*all countries participate, perfect markets, perfect knowledge, no barriers to technology transfer, gradual transitions, etc.*

In the real world, there is no limit to how inefficient the implementation of policies can be. *This in turn means that costs could be much higher than estimated.*

There may also be opportunities to correct market distortions *(e.g. tax structure changes). And, these could lower costs.*

Towards a Strategic Analytic Agenda

- How DOE Can Use Forum Results:
  Establish agenda for future analytic activities and develop related tools and technical assistance
- Building Collaborations
  Strengthen collaboration between DOE, State and Local Governments, EPA, and others to promote use of renewable energy to reduce air pollution